UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 668 MAY 26, 1915

IMP. BUR. 30 AUG.1915 ENTOM.

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

THE SQUASH-VINE BORER.[1]

By F. H. CHITTENDEN,

In Charge of Truck Crop and Stored Product Insect Investigations.

GENERAL APPEARANCE AND METHOD OF WORK.

One of the most troublesome of the many enemies of squashes, pumpkins, and other cucurbits is the squash-vine borer. In many localities this species surpasses all other squash insects in point of injuriousness.

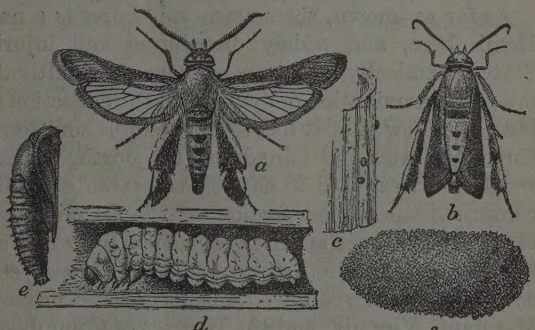

FIG. 1.—Squash-vine borer (*Melittia satyriniformis*): *a*, Male moth; *b*, female, with wings folded at rest; *c*, eggs shown on bit of squash stem; *d*, full-grown larva, *in situ* in vine; *e*, pupa; *f*, pupal cell. All one-third larger than natural size. (Author's illustration.)

Damage is due to the larvæ boring through the stems, causing them to rot at the affected points and become severed from the vine, or so injuring the vine as to cause the leaves to wilt and the plant to die. The presence of the borer feeding within the stem is not apparent at the commencement of the attack, but soon becomes manifest through the presence of the coarse yellowish excrement which it forces from its burrow in the stem and which accumulates on the ground beneath, as well as by the sudden wilting and dying down of the leaves. Wilting occurs soon after the larvæ have made

[1] *Melittia satyriniformis* Hbn.; order Lepidoptera, family Sesiidæ. In early publications this species was generally known as *Melittia ceto*, or *cucurbitæ*.

NOTE.—This bulletin is a revision of Circular No. 38 of the Bureau of Entomology, U. S. Department of Agriculture.

considerable growth within. From one to half a dozen or more larvæ inhabit a stem, and often upward of forty individuals have been taken from a single plant; indeed, one grower has stated that he once cut "142 larvæ from a single vine." The larvæ work with great rapidity and in a very short time are able to injure a plant so that no fruit will mature. Injury is most noticeable near the base of the stems, where in course of time the vine becomes severed from the roots and the whole vine dies.

The parent of this insect is a beautiful, medium-sized moth. The forewings are opaque, lustrous olive-brown in color, with metallic green reflections, and expand from less than an inch to nearly an inch and a half. The hindwings are transparent and veined as shown in the accompanying illustration of the male (fig. 1, *a*). The abdomen is conspicuously marked with orange or red, black, and bronze, and the hind legs are fringed with long hairs—red or orange on the outer surface and black inside. The natural position of the moth when at rest is shown by the figure of the female (*b*).

DISTRIBUTION.

As far as known, the squash-vine borer is a native of the Western Hemisphere, and widely distributed and injurious in the United States practically wherever squashes are cultivated. Available records and examination of material in the collection of the U. S. National Museum show that it has a range embracing territory from the New England States and Canada, in the north, to the Gulf States southward, and westward to the region beyond the Missouri River, which comprises the major portion of the Carolinian and Austroriparian areas of the Upper and Lower Austral life zones and a portion also of the Transition zone. Injury has been observed to be particularly severe in recent years on Long Island and in New Jersey, Delaware, Maryland, Virginia, and the District of Columbia, in the East, and in Kansas and Nebraska in the West. Other States in which injury has been noted include Maine, Massachusetts, Connecticut, Rhode Island, Georgia, Alabama, Mississippi, Louisiana, Iowa, and Michigan. It is evidently of tropical origin, and occurs in Mexico, where it is also widely distributed, and in Guatemala, Panama, Venezuela, Argentina, and the lower Amazon.

FOOD HABITS.

The vines of squash and pumpkin form the chief food supply of this insect, but occasionally it attacks also the gourd, muskmelon, and cucumber. It does not, however, in the writer's experience, infest melons and cucumbers when the other preferred crops are available. The larvæ bore through the stems from the roots to the base of and even through the leaf stalks, and young larvæ may be found even in

the larger veins, into which they bore when the eggs have been placed in such locations, and often attack the fruit. They also penetrate gourds so hard that it is difficult to cut into them with a sharp knife. Larvæ have been observed on the wild balsam apple,[1] which is probably a natural food plant.

Injury is greatest to Hubbard, marrow cymlings, and other late varieties of squash, and is apt to be more acutely felt in small gardens than where crops are grown for market. Even if the plant survives attack it may not bear fruit, and often the grower loses a large proportion of his crop year after year. Not infrequently entire crops are destroyed, and still more frequently every plant in a field is attacked freely.

NATURAL HISTORY.

This species is injurious only in the larval form. Although the larvæ are familiar objects to squash growers, the moths are not generally recognized as the parents of these pernicious borers.

The moths, unlike most others, fly only during the daytime and in the heat of the day. Toward twilight they become less active and may be seen sitting quietly on the leaves of their host plants. Both when in flight and when at rest the moths are singularly wasp-like in appearance.

TIME OF APPEARANCE OF THE MOTH.

Approximately it may be stated that the moth appears as soon as the vines are sufficiently advanced to serve for oviposition and the subsequent subsistence of the borer larvæ within their stems. Indications are that as far south as the District of Columbia the moths make their first appearance in the field some time in May, or, at least, early in June, as larvæ nearly matured have been found by the middle of July. In New Jersey, according to Dr. J. B. Smith, the moths are abroad at or soon after the beginning of June; on Long Island, from the middle to the last of June. In Massachusetts, according to Harris, they appear about the plants the second week in July. We thus have considerable variation in time of earliest appearance, dependent upon season and locality—a variation to be expected in a species of so wide a range.

THE EGG AND OVIPOSITION.

The eggs, which are oval and dull red in color, are laid upon all parts of a plant, from the roots to the buds and petioles, but chiefly along the stems, although in some varieties of squash, it is said, nearer the base of the stem than otherwise. Oviposition is very rapid, the moth flitting from hill to hill, leaving an egg in each. A single moth may lay as many as 212 eggs. The eggs hatch in from six to fifteen days after they are deposited, and the larvæ are said to attain full

[1] *Echinocystis lobata.*

growth four or more weeks later. This period will undoubtedly vary in different temperatures, according to the season of the year when oviposition takes place.

Eggs are shown a little larger than natural at *c* of figure 1, and much magnified at *a* and *b* of figure 2, *c* showing the sculpture.

THE LARVA.

The larva is a soft, whitish, grublike caterpillar of nearly cylindrical form, with a small dark head and a few very sparse hairs on each segment. Larvæ in the earlier stages of growth are illustrated by *d*, *e*, and *f* of figure 2. A full-grown larva is shown in profile within an open stem at figure 1, *d*, and the head and first two thoracic segments appear in figure 2 at *g*. Mature larvæ measure about an inch (25 mm.) in length. In the District of Columbia full-grown larvæ, as already observed, occur as early as July 16; in New Jersey, later in July, and are to be found upon the vines in different stages in October; at Washington, as late as the second week of November.

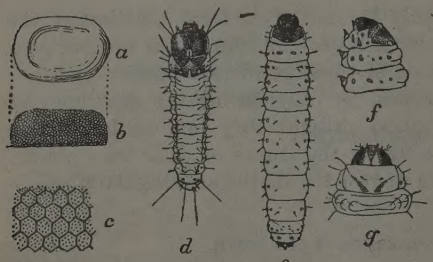

FIG. 2.—Squash-vine borer: *a*, Egg as seen from above; *b*, same from the side, showing sculpture; *c*, sculpture of egg greatly enlarged; *d*, newly hatched larva; *e*, half-grown larva; *f*, head of same from side; *g*, head of mature larva from above. *a*, *b*, and *c*, Much enlarged; *d*, *e*, *f*, and *g*, less enlarged. (Author's illustration.)

After attaining maturity the larvæ desert the stems and enter the earth, burying themselves to the depth of 1 or 2 inches, and form their cocoons, in which they transform to pupæ. The cocoon (fig. 1, *f*) is constructed of silk and coated externally with fine particles of earth, which adhere on account of some gummy secretion of the larva.

THE PUPA.

The pupa, or chrysalis (shown in profile at *e*, fig. 1), measures about ⅝ inch (16 mm.) in length. It is shining mahogany brown in color, and its head is ornamented in front just above and between the eyes with a hornlike process. By means of this the pupa cuts its way out of one end of its cocoon and by the aid of the abdominal hooklike spines forces itself to the surface of the earth before transforming to adult.

NUMBER OF GENERATIONS.

The question of the number of generations produced annually in localities of different temperatures which this insect inhabits has been solved by actual observation, the results serving to indicate that it is practically single-brooded on Long Island and northward; that there is a tendency to two broods in New Jersey, the moths in

exceptional cases completing their transformations late in August or September; that in the latitude of the District of Columbia the species is partially double-brooded, a larger portion of the moths, we may assume, developing as a second generation here than in New Jersey; and that in the Gulf States this species is undoubtedly fully two-brooded.

PREVENTIVE AND REMEDIAL MEASURES.

This borer is an exceptionally difficult insect to control, as ordinary insecticides are of no value after the insect has once entered the vines, and repellents are also practically useless. We are, therefore, dependent upon cultural methods for relief.

Knowing that the insect passes the winter in the fields which it has ravaged, it should be superfluous to caution growers against planting squashes in the same ground in successive years.

EARLY SQUASHES AS TRAPS.

Good results have been obtained by planting as a trap crop and as early as possible a few summer squashes, such as crooknecks and early cymlings, before and between rows of the main crop of late varieties. The summer squashes attract the insects in such numbers as to leave a smaller number to deal with upon the late or main crop. As soon as the early crop is gathered, or earlier if the ground is needed for the main crop, the vines are promptly raked up and burned to destroy all eggs and larvæ which they may harbor, and the same treatment is followed after gathering the late varieties. This method, according to the late Dr. J. B. Smith, has proved profitable where used in New Jersey and should produce good results farther north. Southward, where two well-defined broods appear, it might not be so productive of good, but it should be given a thorough test.

FALL HARROWING AND DEEP SPRING PLOWING.

Experiments conducted by Mr. F. A. Sirrine, of the New York Agricultural Experiment Station at Geneva, N. Y., show that this species can be greatly reduced by lightly harrowing the surface of infested squash fields in the fall so as to bring the cocoons of the vine borer to the surface, where they will be exposed to the elements, and then plowing in the spring to a uniform depth of at least 6 inches, so that the adults will not be able to issue.

OTHER CULTURAL METHODS.

When the vines have attained some length parts of them should be covered over with earth, so that secondary roots will be sent out to support the plants in case the main root is injured by the borer. Keeping the plants in good condition, free from other insects and from disease, and well nourished with the assistance of manure or

other fertilizer if necessary, will also aid the plants to withstand borer attack. When vines are so badly infested as to be incapable of bearing fruit they usually die at once, and they should then be promptly taken out and burned. The old vines should also be destroyed as soon as the crop is made.

CUTTING OUT THE BORERS.

The old-time remedy of cutting the borers out of the vines, although laborious, is useful, and about the only method open for employment after they have entered the vines. As several individuals often infest a single vine, it is best to cut longitudinally, so as not to sever the vine from the root stalk. If the wound made by cutting be afterwards covered with moist soil it will assist it to heal. The location of the borer in the vine can be readily detected by the accumulation of its yellow "frass" or excrement at the point where it is working, and which is kept open for the extrusion of this matter.

CAPTURING THE MOTHS.

This species may be held in partial subjection by keeping a sharp lookout for the parent moths, which are readily seen and not difficult of capture toward dusk or in the cool of the morning, when they are comparatively inactive. The female may then be easily caught, just as she alights on a vine for oviposition. Several persons, including the writer, can vouch for this statement.

SUMMARY.

If the grower would make certain of securing a good crop in localities where this and other enemies of the squash occur in their most destructive abundance, it will be necessary for protection against this borer to observe most of the following precautions, and, if possible, secure the cooperation of his neighbors in their observance:

(1) Not to plant in or near infested ground.

(2) To plant early varieties for the protection of late squashes.

(3) To harrow infested fields lightly in fall and plow deeply in spring, to prevent the moths from issuing.

(4) To encourage the growth of secondary roots by covering the stems with earth.

(5) To destroy dead vines and old plants as soon as the crop is made.

(6) To keep the plants in vigorous condition, free from other insects and disease.

(7) To cut out such borers as may succeed in entering the vines in spite of the employment of other remedial measures.

(8) The capture of the moths before egg deposition is advisable.

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ENTOM.

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

HARVEST MITES, OR "CHIGGERS."

By F. H. CHITTENDEN,

In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTION.

Residents of the South and of the more southern portions of many of the Central States, and especially visitors to these sections, are often subject to great annoyance due to the attacks of minute creatures popularly known as "chiggers" [1] and "red bugs," and incorrectly as ticks. These creatures occur in blackberry bushes, shrubbery, grass, and weeds, and persons walking or sitting down in such localities are liable to attack. "Chiggers" usually enter the skin near the shoe tops or at points below the knees, but sometimes they are jarred from bushes or small trees on to the neck and other exposed portions. Their habit of burrowing under the skin is not normal and brings about their death. Nevertheless the inflammation thus caused may become very painful, and where many of the creatures have attacked a person this may frequently lead to fever or other disagreeable consequences. The desire to scratch the affected spots is very strong, and scratching with the fingernails may easily abrade the skin and might communicate infec-

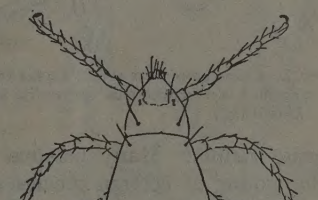

FIG. 1.—*Trombidium:* sp.: Larva, highly magnified. (From Banks.)

[1] The name "chigger" or "jigger" is evidently a corruption of chigoe, the pernicious sand flea (*Sarcopsylla penetrans* L.) of tropical America, a true flea, which crawls under the toe nails of man, producing painful sores which may result seriously if neglected.

NOTE.—This bulletin, which is a reprint, with revision, of Circular No. 77 of the Bureau of Entomology, U. S. Department of Agriculture, treats of the harvest mite and means for the protection and relief of human beings subject to its attack, together with methods of eradication. It will be of interest wherever this pest is troublesome.

tion from the nails or other outside sources. Children, and especially those who begin to go barefoot in grassy places in June to September, are great sufferers from this minute enemy.

WHAT "CHIGGERS" ARE.

These pests are the larval or six-legged forms of harvest mites of the genus Trombidium, the adults of which have eight legs. For present purposes we may consider the harvest mites as a class. In figures 1 and 2 illustrations of some common forms are furnished. The larval harvest mites are of microscopic size, blood red, and shaped somewhat like a common tick, being nearly as broad in front as behind. They belong to the order Acarina and are not true insects (Hexapoda), but are members of a distinct class (Arachnida) along with ticks, spiders, and the like. The parent mites are predaceous on true insects. As early as 1834 Mr. A. L. Dugès[1] made observations on these mites, which, as previously stated, have six legs in the immature or parasitic stage, while the adults have eight. The adults are of different shades of red and are quite visible. Many persons are familiar with the appearance of the young of certain species, as they occur on the under surface of the bodies of grasshoppers and harvest spiders or "daddy-long-legs" (Phalangiidæ) and under the wings of the house fly. Just what species of harvest mites are troublesome to man in the United States is not known, but one of them, perhaps the commonest, is referred to in literature as "*Leptus*" *irritans* Riley.[2]

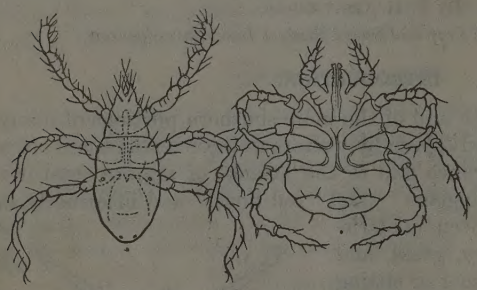

FIG. 2.—*Leptus americanus* at left; *Leptus irritans* at right. Highly magnified, dots under anal extremity indicating natural size. (After Riley.)

SYMPTOMS AND MANNER OF ATTACK.

Soon after the harvest mite burrows under the human skin a small red spot appears (evidently the mite itself gorged with human blood),

[1] Dugès, Ant. Recherches sur l'ordre des Acariens en general et la famille des Trombidiés en particulier. *In* Ann. Sci. Nat. Zool., t. 1, ser. 2, art. 1, p. 36, 1834; see also Megnin, P., Memoire sur les Metamorposes des Acariens en general et en particulier sur celles des Trombidions. L. c., t. 4, sér. 6, art. 5, p. 1–20. 1876; and Murray, Andrew, Economic Entomology, Aptera, p. 129–133, London, 1877.

[2] Riley, C. V. Poisonous insects, p. 745, fig. 2980, New York. 1887. (Extracted from Reference Handbook of the Medical Sciences, v. 5.)

Leptus is a genus founded on the larval Trombidium. Those who may desire further information in regard to the structure of the adult may consult Banks, Nathan: "A treatise on the Acarina, or mites." (*In* Proc. U. S. Nat. Mus., v. 28, p. 30, 31, 1904.)

after which the surrounding surface becomes congested, the affected area spreading until it is from less than a fourth to a half or three-fourths of an inch in diameter. This congestion may manifest itself within less than an hour after exposure or may not be apparent for 12 hours or so, the fever being at its height usually on the second day. The symptoms are apt to be first noticed when the sufferer has removed his clothing at night, or upon awakening from sleep. It sometimes happens that there is little irritation until some time after exposure, but with most persons susceptible to the poisonous effects of these mites irritation is first experienced on the second day. The feverish appearance of the afflicted skin area varies according to the susceptibility of the person attacked. Children dwelling or sojourning in mite-infested localities suffer greatly from these pests, experiencing more severe annoyance than adults, and young women as a rule suffer more than older persons. People with thin, delicate skin and florid complexion are most afflicted by the mites, and with them the congested red spots are proportionately larger and more inflamed and irritating.

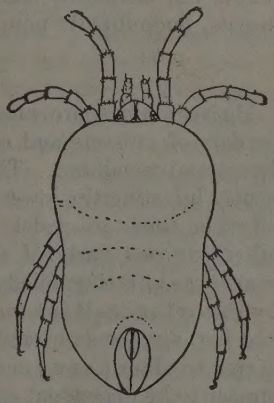

FIG. 3.—*Trombidium* sp.: Adult, highly magnified. (From Banks.)

Many persons, however, as, for example, permanent residents of infested regions, and particularly farm laborers, seem to be practically proof against the toxic effects of harvest mites and go with impunity into places overrun with them. This immunity to poisoning is obviously due to two causes: (1) To outdoor work which toughens the person's skin, especially such portions of the arms and legs as are much exposed to the sun and weather; and (2) to inoculations, due to frequent infection.

The inflamed spots due to the presence of the mites under the human cuticle are often diagnosed as hives, nettle rash, urticaria, or the "wheals," and resemble closely those produced on many persons by the "bites" of fleas and some mosquitoes, but on the second or third day each of the mite-infested areas is usually found surmounted at the middle by a minute vesicle or water blister. This is obviously the most important characteristic of harvest-mite attack. After the subsiding of the inflammation and itching, which takes place in a few days, a small scale or scab frequently forms, leaving on some persons a scar which does not wholly disappear in extreme cases for weeks. The mites naturally attack first those portions of the body which are most exposed—those nearest the ground. They crawl into the

stockings and penetrate the skin about the ankles, frequently below the shoe tops, and are usually found most numerous below the knee. According to the late Dr. John Hamilton, a physician as well as entomologist, the harvest mites enter the larger sweat tubes or pores of the skin, and as these tubes are very tortuous, the progress of the mites is necessarily slow, from 18 to 36 hours being required for them to reach the end. When the lesions caused by these mites are unusually numerous, the sufferer becomes feverish, and sleep is much disturbed. Sometimes the afflicted one becomes frantic and lacerates his flesh by too vigorous and frequent scratching. Erysipelas is known to follow severe attacks, and death resulting from blood poisoning is recorded. These more serious results of infestation are, however, exceptional and, as with the fatalities which in rare cases follow the ordinarily merely painful or annoying "bites" of many insects, undoubtedly point to an impurity of the blood.

HABITAT.

Harvest mites are most abundant in damp locations, along the borders of streams and other bodies of water, and on the edges of forest and woodland. They occur also on trees and shrubbery, evidently infesting the lower surface of the leaves, from which they drop off when these are rudely shaken, and find lodgment on the neck or other exposed parts of the body. Riley describes "*Leptus americanus*" as affecting chiefly the scalp and armpits. In places infested by harvest mites it is a matter of danger to sit down or lie in the grass and herbage for any length of time, as the mites will then have easy access to almost any portion of the body. As a rule these creatures appear to be dependent on the shade and not to live in the direct sunlight, but some forms occur in sunny locations.

These mites are most abundant and troublesome in the Tropics, and become less numerous as we go northward. They are generally distributed in the Gulf States, up the Mississippi River to Missouri and Illinois, and through the Atlantic Coast States to northern New Jersey. They appear to be unknown in New York and New England, or north of latitude 40° in the East.

Trouble from chiggers has also been reported in portions of Tennessee and practically throughout the State of Ohio, because we have record of injury as far north as Sandusky, which is on Lake Erie, Lima, in the northern part of the State, Cincinnati, and Columbus. Reports that these creatures have also been found in other localities may and may not be true at the same time, since with the cultivation of the soil and the destruction of wild bushes and other places of harbor they have practically disappeared. There are reports also of the occurrence of chiggers at Horicon, Wis., and La Fayette, Ind., in Minnesota, and at Belvidere, S. Dak.

Several reports have been received of a plague of these mites in the vicinity of Chicago, Ill., showing similar distribution in that State. Chiggers are well distributed in Kansas, and reports would indicate similar conditions in Indiana and portions of Iowa.

Harvest mites are well known in England and Scotland under this name and as "gooseberry bugs." On the Continent of Europe, also, they are abundant, especially in Belgium and the Netherlands, in parts of Germany, and in France. Indeed, in some of these countries they have at times caused considerable annoyance to the peasantry, whom they have hindered or prevented in the harvesting of certain crops. The mites are troublesome, too, in tropical America, in the West Indies, and in Japan.

LIFE HISTORY.

The life history of a harvest mite, as related by Mr. Nathan Banks, is substantially as follows: The female lays her eggs in or upon the ground, sometimes to the number of 400 in one place. The eggs are usually brown and spherical and have been considered by some early writers as fungi. The chorion or outer skin splits soon after the eggs are deposited, dividing the eggs into halves and exposing the pale vitelline membrane. The larva when hatched is circular or ovoid in outline, and each of its three pairs of legs is tipped with two or three prominent claws. After the larva has become attached to its insect host it elongates and becomes swollen with food. When full-fed it drops off, seeks a convenient shelter, and gradually changes in shape without molting. The new parts are formed under the larval skin, which after a few weeks cracks and discloses the adult Trombidium. The mature harvest mite is predaceous, wandering about and feeding on aphides, small caterpillars, and, in the case of one species, on the eggs of grasshoppers or locusts. It hibernates in the soil or in other sheltered locations and in the spring deposits its eggs. There appears to be a single generation produced each year. Only a few forms have been reared. The larva of one occurs commonly on the house fly in autumn.

REMEDIES.

As harvest-mite infestation is usually contracted by walking or working among blackberry and other shrubbery which harbors them, or by walking, sitting, or lying among grasses or similar herbage along streams or pools, on the edges of marshes, or under trees near such places, it is obvious that the best means of prevention is the avoidance of exposure by susceptible persons. If, however, a bath is taken in hot water, or water containing salt or strong soap, within a few hours after exposure, no ill effects will be experienced. After a longer exposure a bath has practically no effect, and direct remedies are necessary.

Sulphur is a sovereign remedy for mites and is the best preventive of attack. When exposure is unavoidable and where vegetation is not more than 2 or 3 feet high, a sure preventive is found in sifting flowers of sulphur into the underclothes from a little above the knee downward and into the shoes and stockings, or it may be rubbed over legs and ankles. Naphthalene has been successfully used in the same manner. While the sulphur, being inodorous and perfectly effective, is undoubtedly preferable against harvest mites alone, naphthalene is a safeguard against various forms of man-infesting tropical insect pests. Vaseline, pure or mixed with sulphur, will serve the same purpose, but is not so agreeable on account of its oily nature and the certainty of its soiling the clothing.

For most localities these precautions are to be observed through the months of July, August, and a part of September. The mites are seldom bothersome in early June or as late as October, but in exceptionally warm seasons they are apt to be encountered in both months.

If exposure has been unwittingly incurred or precautions have been neglected and the characteristic irritation has set in, warning the patient of trouble to come, a counter-irritant or cooling lotion should be applied directly to the affected parts. For this purpose moderately strong ammonia, applied when the symptoms are first manifest, has offered the best results, and the writer recommends it above all other direct remedies. Bicarbonate of soda, or common cooking soda or saleratus, may be substituted in supersaturated solution. Similar alkaline solutions would probably also serve in counteracting the insect poison, which is acid. These substances should be applied liberally until the irritation subsides. Some persons have testified to the value of a 10 per cent dilution of carbolic acid. Alcohol, camphor, essence of peppermint, and similar preparations are very "cooling," but afford, as a rule, only temporary relief. A dilute tincture of iodine or collodion applied lightly to the affected parts is a good remedy in case of severe suffering. The latter acts by protecting the "sore" spots from the air.

DESTRUCTION OF THE MITES IN THE FIELD.

Much complaint has been made of the presence of harvest mites on lawns and in vegetation in country grounds and along pathways and roadsides, and information has been solicited by many, including officers of country clubs and the like, for methods of eliminating the mites from such locations. This can be accomplished by keeping the grass, weeds, and useless herbage mowed as closely as feasible, so as to expose the mites to the sun. In some cases this can be facilitated by dusting the grass and other plants, after cutting, with flowers of sulphur or by spraying with dilute kerosene emulsion in

which sulphur has been mixed. Grasses on the borders of ponds frequented by cattle, wild blackberry bushes, and similar plants should also be cut down and destroyed in the vicinity of houses and where children and older persons are liable to mite infestation by passing through them. Well-cultivated fields kept free from weeds are not infested with "chiggers," and in the course of time, perhaps a year or two, the measures prescribed, if carefully carried out in grassy locations, should also entirely free these from the pests.

In severely chigger-infested tracts of, say, 400 acres, where there are no bushes or shrubs of value, cattle may be inadequate, and correspondents and others have stated as their experience that after turning sheep into the fields the chiggers were destroyed. Undoubtedly this was due largely to the fact that the sheep kept the grass more closely cropped than cattle would have done, but there is also a belief that the chiggers ascend the legs of the sheep and that the oil or lanoline of the wool is responsible for their death. Hence it is believed that sheep turned into large tracts such as described would accomplish the eradication of the mites more thoroughly and in a shorter space of time than would perhaps any other domestic animal, even including goats, which might be used in some cases.

For the eradication of chiggers on the grounds of wealthy private individuals and clubs the application of ordinary flowers of sulphur might be both cheaply and thoroughly made by the use of one of the dust blowers used for dusting potatoes with Paris green, or by one of the sulphur dusters used for spraying orange trees for the red spider in California. These sprayers are capable of throwing a fan-shaped discharge about 8 feet wide and effect very even and thorough distribution. The cost of application, allowing 50 pounds of sulphur per acre, should be from $1 to $1.50 per acre, and since with one man and a team 30 to 40 acres a day may be covered, the expense of application is not great. Such a duster costs from $65 to $80.

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FARMERS' BULLETIN

COMPLIMENTS OF J. R. HORTON

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Contribution from the Bureau of Entomology, L. O. Howard, Chief.

CONTROL OF THE CITRUS THRIPS IN CALIFORNIA AND ARIZONA.

By J. R. HORTON, *Scientific Assistant, Tropical and Subtropical Fruit Insect Investigations.*

INTRODUCTION.

The citrus thrips,[1] a minute orange-yellow insect, has in the past few years caused extensive damage to citrus fruits in the San Joaquin Valley of California and also occasioned considerable injury in southern California and Arizona orange groves.

The nature and extent of the injury caused by this insect and its life history and habits were carefully studied, and extensive experiments for its control were conducted by the writer during the period from 1910 to 1912. It is the purpose of the present paper to give briefly the practical control measures resulting from these studies.

INJURY.

The citrus thrips is a sucking insect feeding on the plant juices of the leaves, the fruit rind, and the bark of tender stems, in much the same manner as the mosquito draws its food from its victims. For this reason the insect can not be killed by stomach poisons sprayed on the plant, but must be controlled by sprays that kill by contact.

The injury caused by the citrus thrips begins with the seedling orange tree. The leaves are scarred and distorted, and to a certain extent the stock is devitalized. When the seed stock is budded and the foliage of the seedling trimmed off, the thrips attacks the bud. Nursery buds will make a fine, luxuriant growth of 2 or 3 feet in a

[1] (*Euthrips*) *Scirtothrips citri* Moulton; order Thysanoptera, family Thripidæ.

NOTE.—This bulletin is of interest to the citrus growers of the Pacific coast and the Southwest.

season if properly sprayed to protect them from thrips. On the other hand, many nursery trees have the leaves and stems so badly scarred and twisted as to give them a blighted, unsightly appearance, and are so retarded in growth that they must be held in the nursery for a year or more beyond the proper time for sale in order to meet the size requirements, thus decreasing the nurseryman's profit by the cost of the extra care. It sometimes happens that this class of stock is sold along with better trees, and the thrips injury continues for

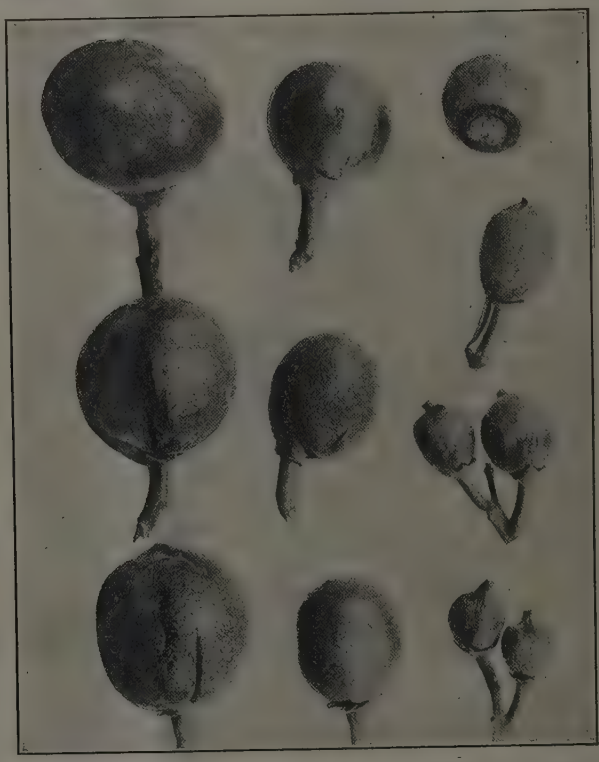

FIG. 1.—Injury to young oranges by the citrus thrips (*Scirtothrips citri*). (Original.)

several years in the orchard. The writer knows of 5-year-old and 7-year-old groves in the foothills of Tulare County which have been held back, principally by thrips, to such an extent that the trees are no larger than 3 and 5 year trees in less infested situations. From the general appearance of such trees it seems evident that they will never attain the size and bearing capacity of trees which have escaped severe thrips infestation in the nursery and during their early years in the orchard.

As the young fruit appears it in turn is attacked (fig. 1), and its market value at maturity is much reduced by the enlarged feeding scars and scabbing (fig. 2). A larger percentage of small-sized fruits than ordinarily develop results, and there is a total loss, as the result of early and severe scabbing, of a proportion of the fruit. To calculate the damage caused by the insect in reducing the grade of the fruit, it is necessary to know the system of grading and the relative market value of the grades. Three packs are usually made in California packing houses at the time of this writing, these packs or grades being variously designated as "Fancy," "Choice," and "Standard"; "Extra Fancy,"

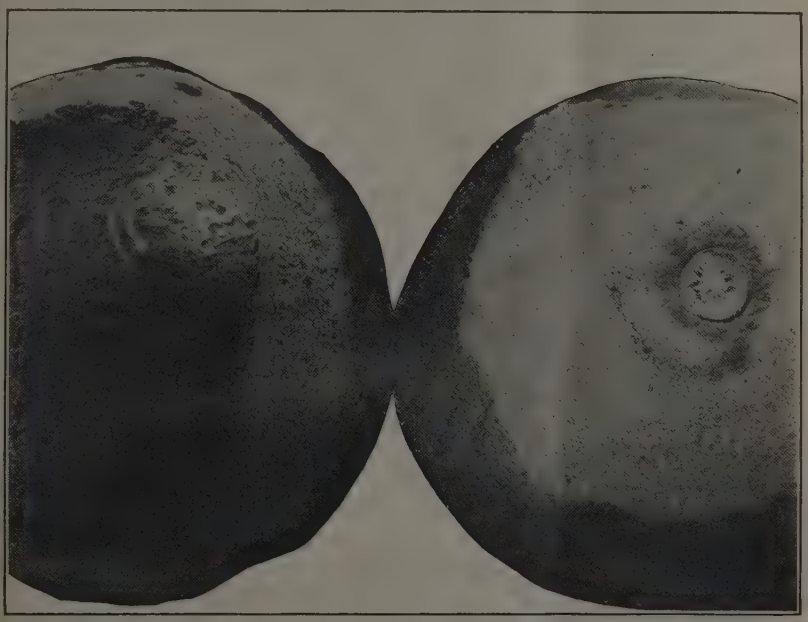

FIG. 2.—Mature oranges, showing injury by citrus thrips. (Original.)

"Fancy," and "Choice"; or "Extra Choice," "Choice," and "Standard." Whatever the terms used there is usually little difference in the quality of fruit of corresponding grades at the different packing houses. In other cases only two divisions are made, the first grade generally being designated as "Orchard Run" and the second or lower grade as "Standard." Under the latter system the quality of the fruit composing the first grade is about the same as would be obtained by placing together all the fruit of the first and second grades of the three-grade pack. Statistics upon the quantity of fruit shipped from the entire San Joaquin Valley and the prices received for it are not available, but from Lindsay and its tributaries 1,525 carloads of navel

oranges were shipped in 1911. The approximate average number of boxes of fruit to the car is 390, making 594,750 boxes for the season's shipment. From examination of thousands of oranges in the field, throughout the district and in many groves, it was calculated that 34 per cent of all the fruit would be classed as first grade so far as thrips injury was concerned, 43 per cent as second grade, and 23 per cent as third grade. Returns received by different packing houses on a total of 358,000 boxes of navels of all grades for the season indicated the following average differences in price per box between the different grades. First-grade fruit averaged 37 cents more per box than that of second grade; the latter 28 cents more than that of third. Fruit shipped in only two grades gave an average difference of 51 cents per box in favor of the first grade. It may be seen from the foregoing data that 43 per cent, or 255,742 boxes, of the Lindsay fruit was reduced to second grade at a loss of 37 cents per box, or $94,624.54; 23 per cent was reduced to third grade at a loss of 65 cents per box, or an additional $88,914.80. There was thus a total loss for the Lindsay district alone of approximately $183,539.34 in the season of 1911 from grade reduction caused by thrips.

SUMMARY OF SEASONAL HISTORY.

In seasons such as 1911, adult citrus thrips first appear in April and increase rapidly during April and May, during which time the insects are congregated largely on the fruit and foliage of the orange. During part of June, July, and August the adults leave the toughening fruit and leaves of the orange and disperse over miscellaneous food plants, and it is during this period of wider separation that mating and oviposition are somewhat checked. In August and September there is a series of flights back to the late summer growths of the orange, where the insects concentrate in large numbers, mating and actively depositing the eggs which produce the insects of the following spring.

The citrus thrips begins to disappear about the middle of October, and after December practically none can be found. There are generally a few larvæ and adults in places on the trees until the early part of January, at which time they disappear completely. The eggs which are deposited in the stems and leaves of the orange in the fall mostly pass the winter successfully, hatching during the ensuing March, April, and May. The seasonal activities of the citrus thrips, as related to orange blossoming, growth periods, and spraying are summarized graphically in figure 3.

SUMMARY OF LIFE HISTORY.

There is a tendency on the part of the citrus thrips to breed throughout the year. All stages of the insect are found on the trees throughout November and December. Larvæ, pupæ, and adults gradually

die off as the weather grows colder, until by the middle of January all have disappeared. The winter is passed only in the egg stage. Eggs deposited in the leaves and stems, mostly during late August, September, and October, hatch and the larvæ appear in March, April, and May.

The average duration of the egg stage of summer generations varies from 10 to 18.8 days during May and June, 6.8 to 8.5 days in July and August, and 17 to 18.8 days in September and October.

The average larval stage varies from 6.6 to 13.7 days during April and May, 4.2 to 9 days from June to August, and 6.7 to 11.2 days in September and October.

The average pupal stage varies from 4.7 to 13 days during April and May, 2.8 to 5.1 days from June to August, and 5 to 19.9 days from September to November.

Pupation takes place in crevices on the tree trunk, in dead leaves and rubbish under the trees, and under clods and particles of trash

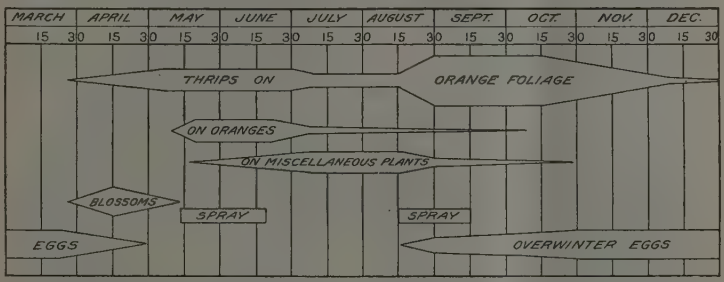

FIG. 3.—Graphic illustration of the seasonal activities of the citrus thrips as related to blossoming and later growth periods of the orange, and indicating also the spray periods. (Original.)

on the ground, but never in the ground. The pupa is naked, does not construct a cell, and is at all times capable of locomotion.

The average duration of adult life is from 25 to 35 days, with extreme instances running to from 46 to 49 days. Adults can live from 2 to 6 days only without food.

The number of generations in a season will depend upon the character of the season. An early, warm spring followed by a prolonged, hot summer may result in the production of eight or more generations. In seasons such as 1911, six full generations may be expected between the middle of April and the first of November. For purposes of control the citrus thrips must be treated as an insect having only a single generation a season, and with an egg-laying period extending from April to November.

REMEDIES FOR THE CITRUS THRIPS.

Certain measures against the citrus thrips have been persistently recommended in spite of abundant evidence of their inapplicability. These are usually directed against the pupal stage and consist in the application of insecticides to the soil, breaking the soil up fine to destroy the insects supposedly pupating there, and burning dead leaves and trash, which accumulate under the trees, to destroy the pupæ. These methods are worthless for the reason that the thrips

FIG. 4.—Resin-wash injury to half-grown oranges sprayed for the citrus thrips. (Original.)

do not go into the soil at all, and only a varying and often small percentage of them pupate in the trash. Fumigation with hydrocyanic-acid gas will reach and kill only the larvæ and a small number of adults, and is accordingly too expensive to use. Distillate-oil emulsions and proprietary emulsions containing distillate, even when used as weak as 2 per cent, stain the ripe oranges, and are otherwise so injurious that it is considered unsafe to use them. Commercial lime-sulphur is not noticeably injurious when used at less than 1 part to 28 parts of water. Resin wash can not be safely used on orange trees at any strength. Where the resin mixture comes into contact with the fruit the epidermal cells are killed and

a shallow brown scab is formed. (Fig. 4.) Where the liquid collects in large drops it forms a thick, amber-to-black scab which does not slough off readily. About 20 per cent of the fruit at picking time was thrown into the lowest grade owing to scabbing through the use of the weakest resin wash.

There is only one cheap and effective method of citrus-thrips control, viz, the application at high pressure of contact insecticides, preferably mixtures containing sulphur in solution. Sulphur mixtures at the proper strength have given uniformly high killing results and have thus left no doubt as to their insecticidal power over this species. They further show a more or less marked tendency to repel the insects and prevent rapid reinfestation of sprayed trees.

SPRAY MIXTURES AND DILUTIONS.

Of the large number of combinations of insecticides tested, the following have given the best results, and any of the mixtures here recommended may be relied upon to do good work:

1. Commercial lime-sulphur.—If the lime-sulphur is of a density of 36 degrees on the Baumé scale, dilute 1 gallon with 56 gallons of water; if of a density of 33 degrees Baumé, dilute 1 gallon with 50 gallons of water.

2. Sulphur-soda solution.—Two gallons of the stock solution, prepared as described on page 8, diluted with 25 gallons of water.

3. Commercial lime-sulphur and blackleaf tobacco extract (40 per cent nicotine sulphate).—Dilute 1 part of the commercial lime-sulphur, if 34 to 36 degrees Baumé, with 86 parts of water; if 30 to 33 degrees Baumé, with 75 parts of water. Then add 1 part of the tobacco extract to 1,000 parts of the lime-sulphur diluted as above.

4. Blackleaf tobacco extract (40 per cent nicotine sulphate).—Dilute 1 part with 800 parts of water.

COMMERCIAL LIME-SULPHUR.

The commercial lime-sulphur, diluted with water and without the addition of other chemicals, is preferred to any of the other insecticides because of its cheapness and convenience in mixing. Very good grades of lime-sulphur can be purchased in the market at a reasonable price, and since the preparation of this product requires care and experience, and as it must be made fresh each time or special precautions taken to store it in air-tight containers, its home manufacture is not advised. When necessary to carry the market product over a season it is essential to protect it absolutely from the air, as it rapidly loses its insecticidal power when exposed through leaky barrels or an open bung.

SULPHUR-SODA SOLUTION.

Another mixture containing sulphur as the most important ingredient is made by dissolving sulphur with the aid of caustic soda, according to the directions given below. This mixture, though

practically as effective in controlling the citrus thrips as lime-sulphur, can not be purchased ready-made and is therefore less convenient to handle. Furthermore, at the present writing it costs just as much per dilute gallon as the factory-made lime-sulphur.

The sulphur-soda stock solution is prepared as follows:

Powdered sulphur	30 pounds.
Powdered caustic soda (98 per cent)	15 pounds.
Water to make	30 gallons.

The sulphur is made into a paste with water, and while the mixture is being constantly stirred the soda is added in sufficient quantity to start boiling. As boiling becomes violent a little water is added to retard it. When the sulphur has all been taken into solution enough water should be added to bring the stock solution up to 30 gallons. If made according to the foregoing directions the final product will be a clear, amber-colored liquid much resembling good commercial lime-sulphur.

PLAIN TOBACCO EXTRACTS.

Tests with plain tobacco extracts without the addition of lime-sulphur or other preparations have given very good results when the tobacco has been used at sufficient strength. Tobacco extract containing 40 per cent nicotine used at the rate of 1 part to 800 parts, liquid measure, of water is quite satisfactory; when diluted at the rate of 1 part to 1,600 parts water, however, its efficiency is noticeably lowered. It can not be recommended for this work in solution weaker than 1 to 1,000, and should preferably be used at the rate of 1 to 800. The commercial tobacco extract containing a high percentage of nicotine sulphate is very convenient to handle and costs approximately $0.016 for each gallon of the diluted spray, when used at the rate of 1 part to 800 parts of water.

TIME AND NUMBER OF SPRAY APPLICATIONS.

Unfortunately no specific dates, which will hold for every season, can be fixed for the applications of the spray. The investigations of the seasons of 1910 and 1911 have shown that the date on which the thrips first become numerous and injurious and the navel-orange blossoms lose their petals varies as much as 30 days in certain seasons, due to the nature of the spring weather, and, further, that it varies in different orchards in the same season. The greatest injury to the fruit is done between the time the petals fall and the fruit is half grown. It has been demonstrated that three applications of the insecticide are necessary during this period to prevent marking of the fruit. The first spring growth has usually hardened by the time

the petals have all fallen, and the thrips then seek the young fruit. The petals do not all fall at once, but come down gradually, and the transfer of thrips is therefore gradual.

The first application should be made as soon as four-fifths or more of the petals have fallen. This checks the insect at a time when the orange is most susceptible of deep injury and when the blossoms have passed the period at which pollination might be interfered with by the spray.

After the first application more larvæ will issue from eggs deposited in the very young fruit, and additional adults will appear from the specimens pupating at the time of the application. The second application must therefore be timed to prevent this renewed attack, which may be expected to reach the danger point in from 10 to 14 days after the first spraying. This second spraying should not be too long delayed, as a comparatively few larvæ may, by their persistent habit of feeding in a circle about the base of the fruit, cause considerable injury. Special effort should be made to drench all the fruit as well as the few remaining tender leaves thoroughly, as it is here only that the insects occur.

The third application may be longer delayed if the first two have been thorough and well timed. It generally takes the insects from two to three or four weeks to become dangerously numerous again, as they reinfest the sprayed trees very much more slowly after the second application.

After the third application the fruit rapidly loses its attractiveness, and the insects then find it necessary, in order to secure food, to spread out over the few remaining tender orange leaves and certain miscellaneous food plants. During the latter part of August and in early September there is usually another abundant growth of shoots upon which the thrips congregate in great numbers. A fourth application in late August or more probably in September should be timed to catch the insects as soon as they become numerous and before any great amount of leaf injury appears.

The importance of protecting this growth is evident to those familiar with the stunted condition of orange trees in certain orchards of Tulare County as the result of continuous feeding of large numbers of thrips during the first five or six years of growth. The writer has in mind an orchard in which trees five years from the nursery are no larger than the average 2-year-old trees in localities more favorably situated with regard to thrips, and which each year have a very large percentage of the leaves so severely injured that they roll up into tight curls.

SPRAY APPLICATIONS TO NURSERY STOCK.

While definite dates can not be given for the application of sprays to nursery stock, it follows in the case of trees budded in the fall, where the original stock is allowed to put forth a good growth in the spring, that it is sometimes advisable to spray during April, but only when thrips have become quite numerous and for the purpose of ridding the trees of them before the scion has grown sufficiently to attract them. Preferably the stock should be largely cut back as soon as the bud is well under way, and this is generally done in Tulare County before May 1. The prunings should be burned in every case to destroy eggs and larvæ which may be present. The growing scions must then be watched carefully, and as soon as thrips appear in numbers spraying should begin. They should be further watched with the same care throughout the remainder of the growing season and sprayed as often as the abundance of thrips makes them liable to severe injury. Nursery stock will usually require from three to five applications a season, depending largely on the amount of growth it produces. Once the scion has completed its first growth and become distasteful to thrips the next most important growth will usually occur late in July or in August.

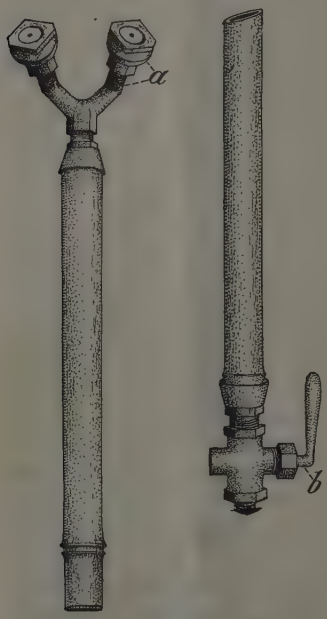

FIG. 5.—Correct spray rod and nozzle connections: *a*, Two nozzles fitted on "Y" branch; *b*, shut-off at base of spray rod. (Original.)

To summarize, the first application should be made when thrips begin to get numerous on the spring growth, usually between April 15 and May 15, after which from two to four further applications will be necessary, according to the conditions of infestation.

SUGGESTIONS ABOUT SPRAYING.

The gasoline-power outfit, by reason of its large nozzle capacity, simplicity, reliability, and comparatively low cost of operation, is the only class of sprayer here recommended for spraying bearing orchards, young orchards in excess of 10 acres, and large nurseries. Hand-power outfits, when of the right type and capable of maintaining a pressure of not less than 125 pounds, are suitable and even preferable

for spraying seed-bed and nursery stock, and they may also be used in young orchards of small acreage.

The spraying outfit should be on hand, set up, and in perfect running condition not later than April 1, and the insecticide materials at hand and conveniently located near the water supply, and as close as possible to the orchard or nursery to be sprayed. It is necessary to order supplies not later than the January or February preceding the spraying operations in order to insure having the material at hand when wanted.

HOW TO SPRAY BEARING ORCHARDS.

It is best to use only two 50-foot leads of hose on a power outfit, with 10-foot rods each fitted with a "Y" (fig. 5) which is angled to handle two nozzles. The latter should be of the large chamber type, with disks bored to one-sixteenth inch, and should throw a double cone of spray which breaks into a fine mist at about 4 feet (fig. 6). The first application should usually be started just before all the petals are down. While the sprayer is being driven between the rows each rodman should begin work at about the middle of his tree on the side away from the sprayer and work around the tree until he meets the starting point; he should then switch to the same point on the next tree without shutting off the nozzles and with as much economy of movement as possible. (See figure 7, which shows easy and correct position for spraying.)

FIG. 6.—Mist spray from twin nozzles. (Original.)

The nozzles should be held about 2 feet from the tree so that the broad portion of the stream plays upon fruit and leaves. The trees should be swept from tip to base, special attention being given to the fruit and the tender growth, where the insects congregate. The pressure, if maintained at 150 pounds or more, will turn the leaves over so that both sides will be sprayed. No

attention need be paid to the inner portions of the tree, as thrips do not occur there.

One should not attempt to spray too many trees with a single outfit, and an application once commenced should be finished within 10 days. It has been found after much experience that only about 25 acres of from 12 to 18 year old trees or 50 acres of from 5 to 7 year old trees can be successfully handled with one gasoline-power sprayer. This is calculated on the basis of ten 200-gallon tanks of spray per day, allowing 8 gallons per tree for trees from 12 to 18 years old or 4 gallons for trees from 5 to 7 years old, allowing 100 trees to the acre. It is a common mistake to use the wash too sparingly and to try to get over the ground too fast. Table I, published also in a former report,[1] was prepared to show approximately the correct amounts to apply to trees of different ages, and from it the quantity of spray material required for the season may be estimated.

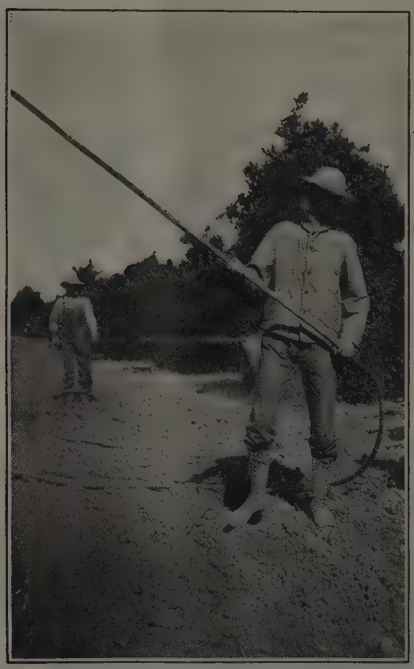

FIG. 7.—Correct position of operator in spraying. (Original.)

TABLE I.—*Quantities of liquid required in spraying for the citrus thrips.*

Age of trees.	One application.	
Years.	Gallons dilute spray per tree.	Gallons per acre of 100 trees.
2 to 3...	2	200
5 to 7...	4	400
8 to 10..	5	500
12 to 18.	8	800

[1] Jones, P. R., and Horton, J. R. The Orange Thrips: A Report of Progress for the Years 1909 and 1910. U. S. Dept. Agr., Bur. Ent., Bul. 99, pt. 1, iv+16 p., 2 fig., 3 pl., Mar. 6, 1911. See p. 15.

The spraying must be very thorough, and to be effective the insects must actually be hit by the spray. It will very much improve the results if the rodmen are shown the insect they are to spray for and just where it will be found in greatest numbers. In this way the object of spraying is made definite. By keeping the thrips reduced to a minimum during the period between the dropping of the petals and the time when the fruit is half grown, most of the fruit scarring and the leaf curl of the early summer growths of foliage can be prevented. An application at the proper time in late August or in September will prevent the severe leaf curling which usually occurs to all late summer growths.

HOW TO SPRAY NURSERIES AND YOUNG TREES.

For large nurseries, where the gas-engine outfit can be advantageously used, it is preferable to the hand outfit. Two 25-foot or even 15-foot leads of hose and 12-foot spray rods are generally most convenient for this work. However, when an outfit has already been fitted with 50-foot hose and 10-foot rods, with the intention of spraying older trees as well as nursery stock, this equipment may be made to serve very well for the latter. In such case the excess hose length should be coiled over a peg or bracket fastened to the spray tank or engine hood, so that the young trees will not be injured by the dragging hose. It is preferable in setting out a nursery to leave driveways wide enough to accommodate a sprayer and team at intervals throughout the length of the bed. Where it is desired to have the nursery rows 4 feet apart, which is the usual practice, it is convenient to have wagon room between the fourth and fifth rows from one side, and again between the 12th and 13th, 20th and 21st, etc. With this arrangement eight rows of trees, four either side of the driveway, may be reached each trip, using 12-foot spray rods; eight more rows may be taken on the return trip, etc.

The large chamber-type or single Bordeaux nozzles may be used to good advantage, but the rapidity of delivery of the spray need not be so great as that necessary for orchard work. It is better to progress more slowly, covering all portions of the little trees, without undue waste of liquid. The trees will need attention only when the growth is tender.

COST OF SPRAYING AS COMPARED WITH RETURNS.[1]

Thrips injury to citrus fruits is confined to the rind and does not appreciably affect the eating quality of the fruit. Except in seasons of unusually gross infestation no great amount of fruit is lost entirely by reason of thrips injury. The argument has been advanced that where the fruit is separated into but two commercial grades, which embrace everything fit to ship, as is now largely the case, thrips injury will have but little effect on the price. The damage thrips do to the trees by interfering with the functions of the leaves throughout the early years of growth, however, is generally overlooked. The following statement takes no account of this indirect injury to the trees, which is difficult to estimate, but merely gives the profit realized from producing a better grade of fruit by spraying.

Cost of spraying one acre of 18-year-old navel orange trees.

Labor:	
2 rodmen at $2.50 each per day, cost per acre	$1.22
Driver and team at $5 per day, cost per acre	1.23
Cost of labor per acre, one application	2.45
Insecticide:	
14 gallons lime-sulphur at 14 cents, cost per acre, one application	1.96
Fuel, oil, and miscellaneous:	
Gasoline, 1¼ gallons at 25 cents, per acre, 3 applications	.625
Oil at $1 per gallon, per acre, 3 applications	.025
Repairs and batteries, per acre, 3 applications	.21
Estimated cost of fuel, oil, etc., per acre, 3 applications	.86
Cost of labor per acre, 3 applications	7.35
Cost of insecticide per acre, 3 applications	5.88
Cost of fuel and miscellaneous per acre, 3 applications	.86
Total cost of treating 1 acre of 18-year-old navel orange trees	14.09

Returns from sale of fruit.

Number of packed boxes fruit produced per acre	324
Per cent of fruit raised from second grade to first grade by spraying	18
Boxes raised from second grade to first grade by spraying	58
Difference in price received per box for first-grade over second-grade fruit	$0.51
Amount saved per acre by spraying	$29.58

Profit from sale of fruit.

Amount saved per acre by spraying	$29.58
Cost of spraying per acre	14.09
Clear gain per acre from the treatment	15.49

[1] The figures given upon cost of spraying are based on the Bureau of Entomology's own spraying work in the season of 1911. The number of boxes of fruit given, 324 per acre, was the actual production of the portion of grove under experiment, and as these trees were not at their best and since 18-year-old trees usually produce more than 324 boxes per acre, the saving effected by spraying would tend to be greater in most cases. The difference of $0.51 per box between first and second grade fruit was that which was actually shown by packing-house returns, and practically all the grade reduction was caused by thrips alone.

In the above calculation the cost of spraying an acre of 18-year-old trees is higher than will usually be the case, since, as a rule, the grower is obliged to have a team on hand all the time and may therefore reduce the item of team hire; he may also be able to reduce the cost of labor somewhat in many cases. In seasons of gross infestation, and in certain orchards every season, the returns will be greatly increased over the figures given because of the excessive infestation in such seasons and orchards.

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